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Labor Productivity Slowdown and Technical Progress in the Netherlands

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A step-by-step vintage modeling of productive capacity and labor demand, and a dynamic simulation over the period 1973–1986, indicate that the labor productivity slowdown in the Netherlands can for a large part be ascribed to various aspects of wage policy. Therefore it is not necessarily true that a decline of technical progress growth has been at the root of this labor productivity slowdown. An impulse analysis shows that these conclusions depend on a number of crucial assumptions and parameter values of the vintage model. The influence of real wage costs on scrapping of old capital goods appears to be of major importance in this respect. The same holds for the question whether technical progress is endogenous.

1. INTRODUCTION

Like most industrialized countries, the Netherlands experienced a remarkable slowdown of labor productivity growth in the last two decades. In the period 1952–1972 labor productivity growth of enterprises was on average 4.4 percent per year, and labor productivity growth in industry even amounted to a yearly average of 5.8 percent. The yearly averages of 2.4 percent and 3.9 percent, respectively, for the period 1973–1986 are in sharp contrast with those for the fifties and sixties.

This productivity slowdown is remarkable, as it coincided with an increase of industry-financed R and D expenditure in the majority of the OECD countries over the late seventies and eighties (see Soete et al., 1989). Moreover, it defies the notion of rapid technological progress in the field of electronic computing and informational services (see, e.g., Baily and Gordon, 1988). Therefore, the problem is some-

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times referred to as the productivity (or Solow) paradox. Numerous causes have been put forward, that may explain this paradox, such as a productivity decline of R and D expenditure (the number of patents per unit of R and D expenditure has fallen), more government regulation because of environmental demands, a decline in the quality of management, and even a decline of intelligence (see, e.g., Fase, 1982, and Bishop, 1989). However, the quantitative impact of these various causes is very difficult to assess. Such assessment is often tried by means of a specific method of growth accounting, that is, by measuring the impact of the determinants of total factor productivity (see Maddison, 1987, for a survey). Total factor productivity is defined as the part of output growth that, according to a given specification of the production function, cannot be ascribed to the growth of labor and capital as production factors.

Total factor productivity has been associated with, or even identified as, technical progress. In case of a steady-state growth and a clay–clay (or Leontief) technology with labor-saving technical progress, which has been the centerpiece of modeling of the supply side in Dutch macroeconomic policy models, the growth rate of technical progress is identical to labor productivity growth. In that case the determinants of total factor productivity are identified as causes for the decline of labor productivity growth. However, actual economic developments may deviate from steady-state growth for quite a long time. This is probably true for the Netherlands, where the policy of wage restraint over the last 15 years has led to a lengthening of the life of capital goods and therefore to a (full capacity or structural) labor productivity growth that is below the growth rate of labor-saving technical progress. As a matter of fact, the description of this very mechanism in the Dutch policy models has favored a general consensus on the need for a policy of wage restraint in order to fight unemployment. Moreover, reduction of working time, which has been another element of the employment policy, may have added to the discrepancy between the growth rates of technical progress and labor productivity.

Therefore, it is not necessarily true that the productivity slowdown is caused by a decrease of the growth of technical progress so that the Ministry of Economic Affairs is to be blamed for a deficient technology policy. It might very well be the case that the successful policy of wage restraint is at the root of the slowdown and that the Ministry of Employment should be praised for it. Such a hypothesis is not only relevant for the Netherlands, but for all (industrialized) countries with a successful policy of wage restraint in order to enhance employment.

This article investigates the discrepancy between technical progress and labor productivity using a stylized policy model for the Netherlands, which contains, in a general specification, several elements of the Dutch modeling of productive capacity and labor demand by means of the Leontief technology. Within this framework, it gives a step-by-step analysis of the causes that make labor productivity growth differ from the rate of growth of technical progress. Thus we use a "structural" approach to growth accounting, as opposed to the "reduced-form" approach of determining total factor productivity by means of a production function. Although we do not test for changes in technical progress (as did McHugh and Lane, 1987), we consider both the case of an exogenous "manna from heaven" technical progress and the case of endogenous technical progress. However, the way in which we endogenize technical progress differs somewhat from the fashion of the new endogenous growth theory (see, e.g., Romer, 1986, and Lucas, 1988).

The next section gives a stepwise presentation of our modeling of productive capacity and labor demand. It starts with a simple steady-state growth model. Successively all elements are added that may explain why the economy deviates from steady-state growth. We call this a quasi-vintage approach. In Section 3 we calculate how these successive deviations from steady-state growth may lead to differences between the growth rates of technical progress and labor productivity. Section 4 looks at how endogenizing technical progress affects the working of the model and the calculations on the discrepancy. Whereas Sections 3 and 4 refer to a dynamic simulation (ex post prediction) over the period 1973–1986, Section 5 looks further into the effects of a wage restraint by means of an impulse or "what if" analysis. A sensitivity analysis shows how the relationship between the labor productivity slowdown and the policy of wage restraint depends on crucial parameter values. Section 6 gives the conclusions of this article and the scope for future research.

2. MODELING PRODUCTIVE CAPACITY AND LABOUR DEMAND

The use of the Vintaf-model by the Dutch Central Planning Bureau about 1975 marks a turning point in model-based policy analysis in the Netherlands. The clay–clay vintage approach with embodied labor-saving technical progress by den Hartog and Tjan (1974, 1976) in this model shows that a rise of real wages exceeding the rate of technical progress has caused an increased scrapping of capital goods and hence has reduced employment. The classical policy prescription by this model is a moderation of wages in order to invert the process described above. This modeling of productive capacity and labor demand by a vintage approach has raised much discussion and has led to a ballooning of research on empirical vintage models for the Netherlands (see den Hartog, 1984, for a survey). In spite of critical comments on the model raised in the discussion, it is nowadays clear that the vintage model and the mechanisms described by it have been instrumental in the general political acceptance of the policy of wage restraint in the Netherlands.

This article uses a generalized version of a vintage approach for modeling productive capacity and labor demand. It is based on quarterly data. This approach incorporates various elements of the different specifications of the vintage model, but it does not explicitly model the vintages for each quarter separately. The advantages of this approach as compared to the usual vintage models are that its specification is much more flexible and that scrapping is not dependent on investment data over 60 quarters or more ago. Hence we do not need such long time series on investment. The main differences compared with the usual vintage models are that the present approach makes no explicit distinction between technical and economic obsolescence and that the distinction between embodied and disembodied technical progress depends on parameter values (De Nederlandsche Bank, 1985, and den Butter, 1987).

2A. Simple Growth Model

We start with a simple growth model with Leontief technology and labor-saving technical progress, which generates steady-state growth. The model is given by Equations (1–5) below.

$$k = k_{-1} + i - k_a, \tag{1}$$

$$k_a = 0.015\, k_{-1}, \tag{2}$$

$$y^{nb} = (1/\kappa)\, k, \tag{3}$$

$$a^* = 0.018\, k\, e^{-\Sigma\mu/100}, \tag{4}$$

$$a = a^*. \tag{5}$$

Equation (1) defines the capital stock as the capital stock in the previous period plus investment minus scrapping (the Annex contains a list of symbols). Equation (2) implies that in each quarter 1.5 percent of the capital stock of the previous quarter is scrapped. The value of this coefficient, like all other coefficient values of this study, is based on the empirical literature. In determining these values the outcomes of the Dutch policy models have played a prominent part. The selected scrapping percentage of 1.5 implies an average life of the capital stock of over 15 years. Equation (3) describes the proportionality between the capital stock and productive capacity of enterprises. The capital output ratio κ is set equal to 5. This relatively high value of κ is selected in order to let the data used in this study on production match with the data on cumulated investment. Equation (4) describes the fixed relationship between capital stock and full-capacity labor demand. The amount of labor associated with the capital stock decreases in each quarter owing to labor-saving technical progress. In the basis variant of the model this percentage μ is set equal to 1.25, implying a yearly growth of technical progress of 5 percent. Instead of multiplication by a time trend we use the summation of μ in this equation so as to allow us to change the value of μ in the course of time. The coefficient value of 0.018 in Equation (4) represents the reciprocal of investment costs per employee in the base year, which is 1970. The value of 0.018 assumes that in the base year an investment of about 55.000 guilders (prices of 1977) leads to an extra labor demand of one labor year. Finally, for the time being, Equation (5) equates actual labor demand to full-capacity labor demand.

2B. Capital Saving Technical Progress

The first step towards a more realistic modeling of productive capacity and labor demand is relaxing the assumption of a fixed capital output ratio by allowing for capital-saving technical progress in Equation (3′).

$$y^{cb} = (1/\kappa)\, k\, e^{\Sigma\mu'/100} \qquad (3')$$

We have set μ' equal to -0.225, which implies a negative capital-saving technical progress (or capital-using technical progress) of 0.9 percent per year.

2C. Working Time

Next we assume that the amount of working time influences the relationship between the capital stock and full-capacity labor demand (working time index h is 1 in base year 1970). The coefficient value of 0.5 in Equation (4′) assumes that reduction in working time leads to an extra labor demand of 50 percent of that reduction.

$$a^* = 0.018\,\{1 + 0.5\,(1 - h)\}\,k\,e^{-\mu t/100} \tag{4'}$$

2D Real Wages

Now we introduce the essential feature of the Dutch vintage models, namely the influence of real wage costs on scrapping and hence on labor demand. In Equation (2′) the percentage of scrapping is determined by the scrapping term c_{af}, which is defined in Equation (6).

$$k_u = 0.015\,(1 + 0.25\,[\mu - 1.25])\,c_{af}\,k_{-1} \tag{2'}$$

with

$$c_{af} = \{1 + 0.4\,[\frac{(\dot{w} - \dot{p})_{av} - 4\mu}{4\mu}]\}, \tag{6}$$

where

$$(\dot{w} - \dot{p})_{av} = 1/4 \sum_{j=0}^{3} (\dot{w} - \dot{p})_{-j}.$$

The scrapping term c_{af} is equal to 1 in the case when the growth rate of real wage costs is equal to the growth rate of labor-saving technical progress. In that case we have steady-state growth with a constant life of capital goods. However, when real wage costs surpass the growth rate of technical progress, the scrapping term becomes larger than 1. Then more than 1.5 percent of the capital stock is scrapped in each quarter. This results in a shortening of the average life of the capital stock. When in periods of wage moderation the growth rate of real wage costs is lower than that of technical progress, the model describes the opposite mechanism. Whereas in models with explicit vintages the influence of real wage costs on scrapping is determined by the specification of the vintage model and by the scrapping criterion, the present model describes this relation by a coefficient that has been set to the value of 0.4. This value implies a real wage elasticity of labor demand in the quasi-vintage block of about −0.5. Section 5 discusses a sensitivity analysis on the value of this coefficient.

In clay–clay vintage models with embodied technical progress a lower rate of technical progress leads to a longer economic life of capital goods in steady-state growth. In order to take this mechanism into account Equation (2′) also contains a term that alters the percentage of scrapping if μ differs from its value of 1.25 percent of the basis variant. Calculations in den Butter (1977, 1978) show that a decrease of μ of 1 percentage point on a yearly basis leads to a lengthening of the life of capital goods of one-half to 2 years. For that reason the relevant coefficient value in equation (2′) is set equal to 0.25.

If the scrapping term c_{af} is greater than 1 and economic life of capital goods shortens, the capital stock becomes more efficient as compared to steady-state growth in the case of embodied labor-saving technical progress. Therefore the relationship between the capital stock and full-capacity labor demand in Equation (4″) is modeled to be influenced by the cumulated differences of the scrapping term from unity.

$$a^* = 0.018\,\{1 + 0.5\,(1 - h)\}\,k\,e^{-\Sigma a/100} \cdot e^{-0.01\Sigma(c_{af} - 1)}. \qquad (4'')$$

The corresponding coefficient, which is set to the value of -0.01, describes the indirect substitution between capital and labor under a Leontief technology, in the case when the growth of real labor costs is too high or too low compared with technical progress. Hence this coefficient value determines the extent to which labor-saving technical progress is embodied or not.

2E. Real Interest Rate

Up to now only real labor cost determined the indirect substitution between capital and labor in this model. However, capital costs, represented by the real interest rate, may also be of importance in this respect. Therefore equation (6′) adds a factor to the scrapping term that is greater than 1 when the real interest rate is below average and capital becomes relatively inexpensive, and lower than 1 when the real interest rate is relatively high.

$$c_{af} = \{1 + 0.4\,[\frac{(\dot{w} - \dot{p})_{av} - 4\mu}{4\mu}]\}\,\{1 - 0.015\,[(r - \dot{p}^e)_{av} - (r - \dot{p}^e)_0]\} \qquad (6')$$

with

$$(r - \dot{p}^e)_{av} = \tfrac{1}{4}\sum_{j=0}^{3} (r - \dot{p}^e)_{-j}$$

and $(r - \dot{p}^e)_0$ is the average real interest rate over the reference period.

Inclusion of the real interest rate in the scrapping criterion can be derived from microeconomic theory for profit-maximizing producers under imperfect competition (Malcomson, 1975; den Butter, 1976). According to this scrapping condition, the economic life of capital goods increases with increasing real capital costs. This is because investment costs are expended at the moment when equipment is installed and carry a larger weight the higher is the discount rate for calculating the present value of future revenues. Calculations with a simple version of a clay–clay vintage model with embodied technical progress show that an increase in the real interest rate of 2 percentage points leads to an increase in the life of capital goods of about half a year. This rather small influence implies the coefficient value in Equation (6′) of 0.015.

2F. Cyclical Labor Demand

According to Equation (5′) actual labor demand is set equal to full-capacity labor demand minus that part of full-capacity labor demand that is not employed because of underutilization of the capital stock.

$$a = \text{const} + a^* - 0.5\,(1 - \tfrac{1}{4}\sum_{j=0}^{3} [y/y'']_{-j})\, a^* \tag{5′}$$

with $y'' = y^{nb} \cdot (y/y_{bn})$.

The coefficient value of 0.5 assumes that, as compared to full-capacity utilization, half of the labor associated with underutilization is laid off while the other half remains employed as cyclical labor reserve. In order to link the data on production by enterprises with national product, we define total productive capacity as productive capacity of enterprises multiplied by the exogenous ratio of national income and production by enterprises. The constant term in Equation (5′) is set equal to its mean value in the reference period, given the selected values of the coefficients in the quasi-vintage block. This makes labor demand as calculated by the vintage block on average equal to measured labor demand in the reference period. However, the calibration of the coefficient values and the validation of this block has been performed in such a way that this constant term obtains a small value only.

2G. Modeling the Rest of the Economy

We continue by endogenizing the main explanatory variables of the quasi-vintage model introduced above (with the exception of technical progress, which will be made endogenous in Section 4). Hereto we build the quasi-vintage model into a simple model of the Dutch economy that comprises all main characteristics of the macroeconomic models actually used in policy analysis in the Netherlands. Our model consists of the usual expenditure equations, wage and price equations, demand for money function, a labor supply equation, equations determining the supply of financial assets, and an interest rate equation.

Table 1: Average Labor Productivity Growth

	1952–1988	1952–1972	1973–1986	1973–1979	1980–1986
Enterprises	3.4	4.4	2.4	3.1	1.7
Industry	4.9	5.8	3.9	4.8	3.0

Source: Central Planning Bureau.

Financial flows and stocks are modeled in a consistent way by means of the balance of payments identity, the budget restriction of the government, and the macroeconomic budget restriction. For more details we refer to den Butter (1991).

3. DISCREPANCY BETWEEN TECHNICAL PROGRESS AND LABOUR PRODUCTIVITY

This section describes how the productivity slowdown or, to be more precise, the discrepancy between the growth rates of technical progress and labor productivity in the reference period 1973–1986, can be explained by the consecutive steps of extending the model. To start with, Table 1 and Figure 1 give the actual data on labor productivity growth in the postwar period. As mentioned in the introduction, growth in labor productivity of enterprises was much higher before the

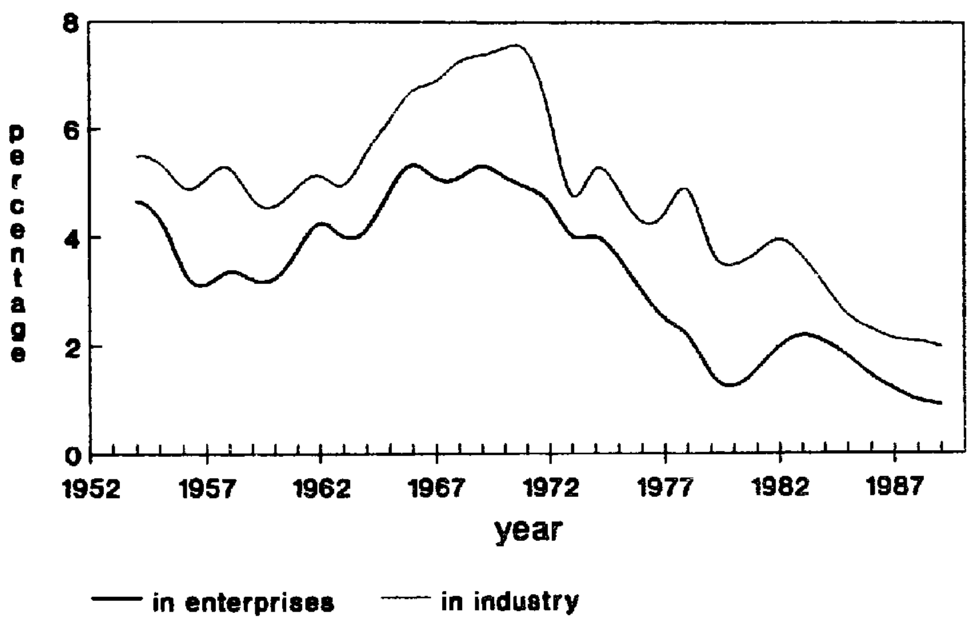


Figure 1. Labor Productivity Growth (5 Years Moving Averages).

Table 2: Average Labor Productivity Growth According to Quasi-vintage Models

	1973–1986		1973–1979		1980–1986	
Model	*lpgfc*	*lpgao*	*lpgfc*	*lpgao*	*lpgfc*	*lpgao*
1. Simple growth	5.0	—	5.0	—	5.0	—
2. Capital-saving technical progress	4.1	—	4.1	—	4.1	—
3. Working time	3.8	—	3.7	—	3.8	—
4. Real wages	2.8	—	3.3	—	2.2	—
5. Real interest rate	2.7	—	3.2	—	2.3	—
6. Cyclical labor demand	3.2	2.1	3.1	3.0	3.2	1.2
7. Demand and monetary sector	3.1	3.1	2.7	4.1	3.5	2.3

Note: lpgfc: Labor productivity growth with respect to full capacity output; *lpgao:* labor productivity growth with respect to actual output.

first oil crisis than thereafter. In the period 1980–1986 the average yearly growth rate fell below 2 percent. Labor productivity growth in industry has traditionally been somewhat higher than that in enterprises, but the productivity slowdown also clearly appears from the data for industry.

The yearly data of Table 1 and Figure 1 are constructed by the Central Planning Bureau (CPB), whereas our model is based on quarterly data derived from the National Accounts of the Central Bureau of Statistics (CBS). In spite of some differences due to definitions and sources, our data show the same pattern in regard to labor productivity growth as those of Table 1 and Figure 1. Therefore these differences are of no importance to our conclusions. In Table 2 we consider two measures of labor productivity growth that summarize the results of the simulations made with the various versions of our model. First Table 2 gives the average growth rates with respect to full-capacity output (or structural growth rate), defined as

$$lpgfc = \text{average growth rate of } y^{nb}/a.$$

Second, Table 2 presents the average labor productivity growth rate with respect to actual output:

$$lpgao = \text{average growth rate of } y^{b}/a \text{ with } y^{b} = y/(y/y_{bn}).$$

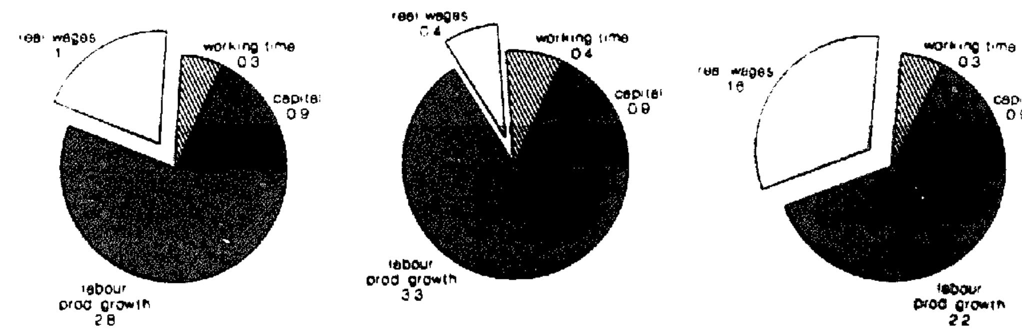
Of course calculation of the labor productivity growth rates with respect to actual output makes sense only in case actual output plays a role in the models.

The first line of Table 2 illustrates that the simple model generates steady-state growth so that labor productivity growth is equal to the rate of labor-saving technical progress, which is, as mentioned in Section 2, set equal to 5 percent per year over the whole reference period. When a negative capital-saving technical progress of 0.9 percent per year is introduced in the model, there still is steady-state growth, with a yearly labor productivity growth rate of 4.1 percent. The third line of Table 2 shows the effects of the introduction of working time into the model. As working time reduction has been quite gradual over the reference period, the negative effects of working time reduction on labor productivity growth are about equal in both subperiods distinguished in Table 2. Because of working time reduction the average labor productivity growth, as measured by the model, has fallen to 3.8 percent.

Next Table 2 looks at the effects of real wages on labor productivity growth. Line 4 of Table 2 shows that over the whole reference period 1973–1986 the development of real labor costs accounts for about 1 percentage point decline in average labor productivity growth. This effect appears to be considerably larger in the second subperiod, 1980–1986. It indicates that wage moderation did, according to the model, indeed account for an important part of the productivity slowdown. It therefore shows that the productivity slowdown should not necessarily be associated with a decline of technical progress.

The results in line 5 of Table 2 indicate that interest rate developments lead, on average, to no further decline of calculated productivity growth. Accordingly, a shortage of credit cannot be designated as an important argument for the productivity slowdown. From lines 6 and 7 of Table 2 we see that the introduction of cyclical labor demand into the model as well as incorporating the quasi-vintage block into a full model does not lead to less labor productivity growth with respect to full-capacity output either. However, it is remarkable that the average labor productivity growth with respect to actual output is much lower in the second subperiod than in the first subperiod. This can be ascribed to the cyclical slowdown at the beginning of the eighties and to the fact that the model does not reckon with the scrapping because of excess capacity that took place in that period (see Gelauff et al., 1985).

Figure 2 summarizes the main results on the productivity slowdown. It illustrates that the model ascribes a considerable part of the discrepancy between the growth rates of labor-saving technical progress and labor productivity to three causes, namely, negative capital-saving technical progress, working time reduction, and real wage moderation. We recall that all calculations above are based on the assumption of



1973-1986 1973-1979 1980-1986

Explanatory note: all simulations assume a constant growth rate of labour saving technical progress of 5%.

Figure 2. Causes of the discrepancy between the growth rates of labor-saving technical progress and labor productivity.

a fixed labor-saving technical progress of 5 percent per year. It is noticeable that the simulated average labor productivity growth according to Figure 2 (and hence according to line 4 of Table 2) appears to be quite in conformity with the actual labor productivity growth of enterprises presented in Table 1. It corroborates our conclusion that the three causes mentioned above are the main determinants of the productivity slowdown, and that it is not necessarily a decline of technical progress growth that is at the root of the productivity slowdown.

4. ENDOGENOUS TECHNICAL PROGRESS

4A. Modeling Endogenous Technical Progress

The full quasi-vintage block of Section 2 incorporates the main mechanisms that are at work when the economy moves from one steady-state growth path to another. Such a move will, for instance, occur in case of a change of the growth rate of labor-saving technical progress, μ. This section investigates the consequences of changes in μ. First we calculate the effects of a simple exogenous change of μ, which, in the period 1973–1976, is assumed to decrease gradually from a yearly average of 5 percent to 4 percent. Such change may be identified as a negative technology shock in the terminology of real business cycle modeling, although we consider a gradual, once-and-for-all decrease in the Leontief framework.

Next we endogenize the growth of labor-saving technical progress μ in a similar way as in the FREIA-KOMPAS model of the Central

Planning Bureau, which is at present used for policy analysis in the Netherlands (see van den Berg et al., 1988). We do so because the consequences of endogenizing technical progress for the working of that model have in our opinion never properly been investigated. As a first step in our step-by-step analysis we consider Equation (7), where the average growth rate of real income acts as the sole determinant of labor-saving technical progress growth.

$$\mu = \text{const} + 0.3\,\dot{y}_{av}, \qquad (7)$$

where $\dot{y}_{av}$ = average growth rate of y over the past five years.

In Equation (7) the constant term const is set equal to the value that over the reference period makes the mean value of μ calculated by (7) equal to 5 percent on a yearly basis. The coefficient, which represents the influence of income growth, is given the value of 0.3, as in FREIA-KOMPAS (Gelauff, 1986). The reason for making labor productivity growth dependent upon income growth is that income growth may lead to more R and D expenditure, which in its turn enhances technical progress. The modeling of technical progress according to (7) is reminiscent of Verdoorn's Law, which links output growth to labor productivity growth. Although Fase and van den Heuvel (1988) find no causal relationship between these two growth rates and therefore conclude that endogenizing technical progress seems not necessarily to be warranted, the lack of causality in Verdoorn's Law can be due to the fact described in this article. The growth rate of labor productivity may differ quite markedly from the growth rate of technical progress.

Second, we consider Equation (7′) for endogenizing μ, where technical progress is determined both by income growth and by the growth rate of real wages corrected for working time.

$$\mu = \text{const} + 0.3\,\dot{y}_{av} + 0.3\,(\dot{w}_{av} - \dot{p}_{av} - 0.8\,\dot{h}_{av} - \text{const}') \qquad (7')$$

where $\dot{w}_{av}$ = average growth rate of nominal wages over the past three years, $\dot{p}_{av}$ = average growth rate of prices over the past three years, and $\dot{h}_{av}$ = average growth rate of working hours over the past three years.

The reason for including the latter determinant in the technical progress equation is that, in addition to direct or indirect capital–labor substitution, high real wage rates may induce extra efforts for introducing new labor-saving techniques. The coefficient value of 0.3 has again been taken from the FREIA-KOMPAS model; const′ is set to

Table 3: Average Labor Productivity Growth with Endogenous Labor-saving Technical Progress

	1973–1986			1973–1979			1980–1986		
Model	μ	*lpgfc*	*lpgao*	μ	*lpgfc*	*lpgao*	μ	*lpgfc*	*lpgao*
7. Exogenous μ ($\mu = 5\%$)	5.0	3.1	3.1	5.0	2.7	4.1	5.0	3.5	2.3
8. Declining μ (μ:5%→4%)	4.2	2.4	2.0	4.4	2.2	3.9	4.0	2.5	0.4
9. μ depends on income growth	5.2	3.3	3.3	5.2	2.9	4.3	5.2	3.6	1.6
10. μ depends on income growth and real wages	5.5	3.5	3.5	5.6	3.1	4.5	5.4	3.8	2.8

Note: μ = Growth rate of labor-saving technical progress; *lpgfc* = labor productivity growth with respect to full capacity output; *lpgao* = labor productivity growth with respect to actual output.

the value that makes the mean of the term within parentheses in equation (7′) equal to zero in the reference period.

4B. Effects on the Discrepancy, 1973–1986

Table 3 shows the effects of endogenizing technical progress on the growth rates of labor productivity as calculated by the models. The starting point is the full model of the last line of Table 2 with a constant exogenous growth rate of technical progress of 5 percent per year. The second line in Table 3 gives the outcomes when this growth rate is gradually reduced from 5 percent to 4 percent. It is no surprise that this reduction of technical progress leads to a decline of labor productivity. However, the model generates second-order effects with respect to actual labor productivity, as the respective differences with the previous model are not consistently equal to 1 percentage point but vary over the subperiods.

The last two lines of Table 3 illustrate that endogenizing technical progress has no systematic influence on the calculated value of labor productivity growth. This result suggests that the labor productivity slowdown in the Netherlands cannot be ascribed to an endogenous decrease of technical progress with income growth and real wages as determinants.

5. EFFECTS OF A WAGE RESTRAINT

The outcomes in the previous sections are based on dynamic simulations of labor productivity growth, given the actual values of the explanatory exogenous variables in the reference period. In order to isolate the effects of the policy of wage restraint, this section looks at the impulse effects of a simulated wage restraint. To that end we simulate a permanent and autonomous 2 percent reduction of the wage rate over the period of 24 quarters (6 years). The baseline projection is based on the values of the exogenous variables in the 4th quarter of 1986. The autonomous reduction of the wage rate starts in the first quarter of the simulation period. The effects of the reduction of wages are measured as differences from the baseline projection.

Table 4 reports the effects calculated with the version of the quasi-vintage model with real wages, the full quasi-vintage block, and the full policy model with exogenous technical progress, respectively. Table 4 shows that the 2 percent wage restraint induces a long-run increase in labor demand of about 1 percent in the quasi-vintage block, whereas, owing to multiplier effects, this increase amounts to about 2.5 percent in the full model. According to the indirect substitution mechanism described by the vintage model, structural labor productivity declines in the case of a wage restraint. This decline appears to be larger when the impulse response is calculated by the full model than by the vintage block only. However, the wage restraint has, mainly because of the improvement of the competitive position, such a favorable cyclical effect on economic activity that the decline of structural productivity is, at the end of the simulation period, fully matched by an increase of capacity utilization. Therefore there is no decline of actual labor productivity after 6 years. It should be noted that in the vintage block income of enterprises is exogenous so that in the left and middle parts of Table 4 the decline of "actual" labor productivity equals the growth of labor demand.

Table 5 gives a sensitivity analysis of the coefficient of scrapping with respect to real wage costs in Equation (6′) in the full policy model. This coefficient is set equal to the value of 0.4 in the basis version of the model. In the two alternatives this coefficient is given a value of 0.6 and 0.2, respectively. From Table 5 it appears that the model's response to a wage impulse depends much on the value of this coefficient. When scrapping depends strongly on wage costs, a wage restraint causes the capital stock to be highly labor-intensive in comparison with the baseline. Therefore we see a huge increase of labor demand and, consequently, a decrease of structural labor productivity. On the other hand, the impulse response of economic activity does not depend much on the value of this coefficient, as the labor intensity of production is not connected with the competitive position. For that reason the middle block of columns of Table 5 also shows a

Table 4: Effect of an Autonomous Reduction of the Wage Rate of 2 Percent (in % of the Baseline Projection)

		(4): Growth model with real wages				(6): Model with full quasi-vintage block				(7): Full model with exogenous μ			
Effect on:	After:	1qu	1yr	3yr	6yr	1qu	1yr	3ry	6yr	1qu	1yr	3yr	6yr
Income of enterprises (y^b)		—	—	—	—	—	—	—	—	−0.5	1.2	2.2	2.4
Labor demand (a)		0.1	1.0	1.5	1.3	0.1	0.9	1.1	1.0	0.0	1.4	2.6	2.4
Technical progress (μ)		—	—	—	—	—	—	—	—	—	—	—	—
Labor prod. full cap. (y^{nb}/a)		−0.0	−0.4	−0.6	−0.6	−0.0	−0.3	−0.3	−0.4	0.0	−0.5	−1.1	−1.1
Labor prod. act. outp. (y^b/a)		(−0.1	−1.0	−1.5	−1.3)	(−0.1	−0.9	−1.1	−1.0)	−0.5	−0.2	−0.4	0.0

Table 5: Effects of an Autonomous Reduction of the Wage Rate of 2 Percent (in % of the Baseline Projection)

		(7): Full model with exogenous μ				(7): Full model, coefficient of scrapping 0.6				(7): Full model, coefficient of scrapping 0.2			
Effect on:	After:	1qu	1yr	3yr	6yr	1qu	1yr	3yr	6yr	1qu	1yr	3yr	6yr
Income of enterprises (y^b)		−0.5	1.2	2.2	2.4	−0.5	1.2	2.3	2.3	−0.4	1.2	2.0	2.5
Labor demand (a)		0.0	1.4	2.6	2.4	0.1	2.0	4.4	4.0	−0.0	0.8	1.5	1.8
Technical progress (μ)		—	—	—	—	—	—	—	—	—	—	—	—
Labor prod. full cap. (y^{nb}/a)		0.0	−0.5	−1.1	−1.1	0.0	−0.8	−1.7	−1.8	0.0	−0.3	−0.7	−0.8
Labor prod. act. outp. (y^b/a)		−0.5	−0.2	−0.4	0.0	−0.5	−0.8	−2.0	−1.7	−0.4	0.4	0.5	0.7

large decline of actual labor productivity. When there is little scrapping associated with wage costs, the increase of capacity utilization due to the rise in demand outweighs the decline of structural labor productivity so that actual labor productivity increases in the long run. This is shown in the third block of columns of Table 5.

Table 6 gives the results of the impulse analysis in the versions of the models where technical progress is made endogenous. The first block of columns relates to the case where technical progress depends on income growth only. In the second block of columns of Table 6 the influence of income growth on technical progress is doubled as compared with the previous version of the model. Hence the respective coefficient is set to a value of 0.6. The third block of columns of Table 6 relates to the version of the model in which technical progress depends both on income growth and on real wage growth. In the last block of columns of Table 6 the influence of real wages on technical progress is doubled in comparison with the basis version of this model. Its coefficient is given the value of 0.6.

All simulations of a wage restraint in this article show that according to the full model the Keynesian fall in demand because of lower wages has a dominant influence on economic activity in the first quarter of the simulation period only. Thereafter the positive influence of the improvement of the competitive position and of the rise in labor demand on economic activity is much stronger so that total income rises. It implies that an income-dependent technical progress also rises. This rise causes the capital stock to become less labor-intensive than in the case of exogenous technical progress. For that reason the long-run increase in labor demand due to the policy of wage restraint is somewhat lower according to the model with income-dependent technical progress than according to the model with exogenous technical progress. This is shown by comparison of the results in the first block of columns of Table 6 with those in Table 4 or 5. Now the negative effect of the wage restraint on structural labor productivity is smaller than with exogenous technical progress, and the effect on actual labor productivity becomes positive after 6 years.

These effects are magnified when the dependence of technical progress on income growth becomes stronger. The results in the second block of columns of Table 6 show that the effects of labor saving and less scrapping in the case of a wage restraint almost compensate each other at the end of the simulation period so that the decline in structural labor productivity is about nil in comparison with the baseline. According to this version of the model actual labor productivity rises

Table 6: Effects of an Autonomous Reduction of the Wage Rate of 2 Percent (in % of the Baseline Projection)

Effect on: After:	(9): μ depends on income				(9): Idem, coefficient of income 0.6				(10): μ depends on income and real wages				(10): Idem, coefficient of real wages 0.6			
	1qu	1yr	3yr	6yr	1qu	1yr	3yr	6yr	1qu	1yr	3yr	6yr	1qu	1yr	3yr	6yr
Income of enterprises (y^b)	−0.5	1.2	2.2	2.6	−0.5	1.1	2.2	2.7	−0.5	1.1	2.1	2.3	−0.4	1.1	1.9	1.9
Labor demand (a)	0.0	1.4	2.4	1.9	0.0	1.3	2.1	1.2	0.1	1.7	3.4	3.0	0.2	2.0	5.0	5.5
Technical progress (μ)	−0.5	1.4	2.4	1.6	−1.0	2.7	4.7	3.5	−4.5	−5.1	−3.4	2.9	−8.9	−13.1	−12.8	0.3
Labor prod. full cap. (y^{nb}/a)	0.0	−0.5	−0.9	−0.6	0.0	−0.4	−0.7	−0.1	−0.0	−0.7	−1.6	−1.4	−0.1	−0.9	−2.6	−3.0
Labor prod. act. outp. (y^b/a)	−0.5	−0.2	−0.2	0.7	−0.5	−0.2	0.1	1.5	−0.5	−0.5	−1.3	−0.7	−0.6	−0.8	−2.9	−3.4

considerably on the long run because of the favorable demand effects of the wage restraint.

Things are somewhat more complicated when technical progress also depends on real wages. In that case a wage restraint leads to a decline in technical progress in comparison with the baseline in the first part of the simulation period. This is illustrated by the third and fourth blocks of columns in Table 6. As production is now much more labor-intensive, the positive effects of a wage restraint on labor demand are larger than in the case of exogenous technical progress. Accordingly, labor productivity is lower than with exogenous technical progress and even actual labor productivity now stays under baseline level. At the end of the simulation period, when technology has been fully adapted to the new level of wages, the positive influence of enhanced economic activity on technical progress again becomes of importance. That is why technical progress ends up above baseline level when it depends both on real wages and on income.

The results of Table 6 show that endogenization of technical progress has a substantial influence on the working of the model with respect to a policy of wage restraint. Whereas the effects on economic activity and on labor demand remain positive throughout, the relationship between wages and labor productivity fully depends on the modeling of technical progress.

6. CONCLUSIONS

This article shows that wage policy may partly explain the labor productivity slowdown in the Netherlands. More specifically, in the context of a vintage model with indirect and gradual substitution between labor and capital, a policy of wage restraint leads to a discrepancy between the rate of labor-saving technical progress and labor productivity growth. We have calculated that in the reference period 1973–1986 wage moderation has accounted for a structural labor productivity growth that is on average 1 percentage point below the rate of labor-saving technical progress. Moreover, about 0.3 percentage points of the discrepancy mentioned above can be ascribed to working time reduction and another 0.9 percentage points to negative capital-saving technical progress. Admittedly, the latter outcome follows immediately from our assumption on this type of technical progress. These calculations indicate that the labor productivity slowdown should not necessarily be associated with a decline of the growth of technical progress.

The main aim of this article is to illustrate how the relationship between technical progress and labor productivity depends on the modeling of labor demand and productive capacity. We use a general specification that includes a number of mechanisms at work in various types of vintage models. The relative importance of these mechanisms can, in our specification, be steered by coefficient values. Hence, it allows us to perform a sensitivity analysis on the specification of the vintage model and on the assumptions on, for example, technical progress and scrapping implicit in the model. This "structural" approach to growth accounting has the following advantages over the usual "reduced form" of calculating total factor productivity by means of a production function:

A good distinction is made between technical progress and productivity growth.
It shows structural effects of technology shocks.
It shows feedback mechanisms in case of endogenous technical progress.

The disadvantages of the "structural" approach are as follows:

It depends on the structure of the models and on the order in which the various blocks are added.
Parameter values are difficult to estimate, since technical progress is unobservable (just as most structural models contain numerous unobservables).

Impulse simulations in this article show that assumptions on the following aspects are of crucial importance for measuring the effects of a policy of wage restraint on labor productivity:

the type of technical progress (labor-saving versus capital-saving; embodied versus disembodied);
the influence of real wage costs on scrapping (the scrapping criterion);
endogenization of technical progress.

In spite of the many different types of vintage models that have been constructed for the Netherlands, little reliable empirical knowledge is available on these assumptions. This is most probably due to the fact that the information content of macroeconomic data is too poor to allow us to discriminate between these assumptions. To that end we would need more microeconomic information on production, technological development, and labor demand.

List of Symbols

a	labor demand by enterprises
a^*	full-capacity labor demand by enterprises
h	index number of hours worked in enterprises (1970 = 1)*
i	volume of gross fixed investments (enterprises)
k	volume of capital stock
k_a	scrapping of capital stock
p	price index of gross national product (1977 = 1)
$\dot{p}$	rate of inflation
$\dot{p}^e$	inflationary expectations
r	(long-term) interest rate
w	wage level
$\dot{w}$	wage inflation
$\dot{w}^e$	expected wage inflation
y	volume of (gross) national product
y/y_{bn}	ratio of national product and production by enterprises*
y^b	production of enterprises
y^{nb}	productive capacity of enterprises
y^{nt}	total productive capacity
κ	capital output ratio*
μ	labor saving technical progress
μ'	capital saving technical progress*

Note: Asterisk indicates exogenous in all models.

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